DESCRIPTION

ALUMINATE PHOSPHOR AND PROCESS FOR PRODUCING THE SAME

TECHNICAL FIELD

The present invention relates to a novel aluminate phosphor capable of emitting fluorescence in a violet to blue-green region by ultraviolet (UV) excitation. Particularly, the invention relates to an UV-excited phosphor which comprises europium-activated strontium aluminate and which is capable of emitting light in a violet to blue-green region throughout a broad composition range. The invention also relates to a method for efficiently producing the phosphor by mixing metal components homogeneously using a chelating agent.

BACKGROUND ART

A phosphor including aluminate as a matrix is widely put in practical use as an UV-excited phosphor emitting light mainly in a blue to green region. Development of a vacuum UV-excited light emitting diode, like plasma display panels (PDPs), has been conducted actively. A vacuum UV-excited light emitting diode is excited by vacuum UV rays which are radiated by rare gas discharge to emit light. An aluminate phosphor for PDP capable of emitting light in a blue to green region has been in practical use.

Aluminate is represented by a general composition formula: $xMO.yAl_2O_3$, wherein M is a divalent metal (mainly, alkaline earth metals). Phosphors of various compositions are produced by introducing a plurality of divalent metals as the metal M, or doping a rare earth metal, Mn or the like as an activator to the M site. For example, a phosphor in which Ba and Mg are used as the metal M and Eu is doped as an activator at the Ba site is ascertained to emit a blue fluorescence by UV excitation.

Representative examples thereof include $BaMg_2Al_{16}O_{27}$: Eu disclosed in Japanese Examined Patent Publication No. Shou 52-22836, and $BaMgAl_{10}O_{17}$: Eu disclosed in Japanese Unexamined Patent Publication No. Hei 08-115673. A phosphor, in which the amount of Ba or Al in the $BaMgAl_{10}O_{17}$: Eu is increased or part of the Ba with Sr is replaced, prevents thermal degradation caused by a baking treatment (Japanese Unexamined Patent Publication No. 2000-226574). A phosphor resulting from doping Eu as an activator on aluminate of magnetoplumbite structure is also known (Japanese Unexamined Patent Publication No. 2001-240856).

For example, $BaAl_{12}O_{19}$: Mn and $BaMgAl_{14}O_{23}$: Mn resulting from doping Mn as an activator on aluminate are UV-excited green-emitting phosphors. In order to improve emission characteristics, a lanthanum magnesium aluminate green-emitting phosphor activated with Ce or Tb is known (Japanese Unexamined Patent Publication No. Hei 06-240252). A Ce-activated (Mn-coactivated) green-emitting phosphor that is a manganese-substituted barium calcium aluminate phosphor in which a part

of Ba is substituted for Zn and the remaining Ba is substituted for Sr is also improved emission characteristics (Japanese Unexamined Patent Publication No. 2000-290647). As another phosphor, a europium-activated strontium aluminate shows blue-green color with a peak emission wavelength at 493 nm.

So-called long persistence phosphor having a long afterglow characteristic is known in aluminate phosphors. A phosphor comprising $MAlO_4$ (M means at least one metal element selected from Ca, Sr and Ba) as a matrix, Eu as an activator, and other rare earth elements as coactivator has a phosphorescence property (Japanese Unexamined Patent Publication No. Hei 07-11250). Other examples include a phosphor in which aluminum of an aluminate matrix is replaced by boron (B) and afterglow characteristics is improved by stabilized its crystal (Japanese Unexamined Patent Publication No. Hei 08-73845). A phosphor comprising $Sr_2Al_6O_{11}$ as a matrix, to which europium as an activator or europium and dysprosium as co-activators have been added, is also known (Japanese Unexamined Patent Publication No. 2000-63823).

As mentioned above, a conventional aluminate phosphor comprises oxides including three or more sorts of metals. In a preparation of such phosphor, mixing metal components homogeneously is important.

Most of above-mentioned phosphors are produced by a classic method, namely called a solid phase method, in which a multi metal oxide is obtained by mixing solid phase raw materials in a desired metal composition ratio,

followed by firing. In the solid phase method, because two or more sorts of metal oxides are mixed in a solid phase state, the resultant is apparently in a heterogeneous phase in a microscopic view no matter how the metal oxides are intended to be mixed homogeneously. No matter how skillfully the metal composition ratio or the amount of metal elements doped is controlled, or even if the composition ratio of metal components included in each particle is controlled as desired, it is theoretically impossible to produce a phosphor having a completely homogeneous metal distribution in each particle.

In order to produce a phosphor of homogeneous multi metal oxide or aluminate composed of a plurality of metal oxides like that mentioned above, it is necessary to prepare a precursor of homogeneous multi metal composition. Further, a preparation of such a homogeneous precursor requires synthesis in a homogeneous state from raw materials. A liquid phase method based on a chemical process, as exemplified by sol-gel method or coprecipitation method, is known to be capable of preparing a phosphor of homogeneous multi metal oxide. However, in such a conventional liquid phase method, production cost is high and producing operations are very complicated. Further, it is impossible to avoid that a metal composition of a precipitate or a powder formed during hydrolysis, neutralization, precipitation or the like becomes heterogeneous even if that of a solution is homogeneous. This is because a hydrolysis reaction rate, a solubility product and the like is different on each metal compound. It is conceivable that fluorescent characteristics of composite oxide or aluminate phosphor is

affected not a little by such a heterogeneousness of metal composition.

The present invention was completed under such circumstances. It is an object of the present invention to develop a novel UV-excited aluminate phosphor having a homogeneous composition and capable of emitting a high-level fluorescence. A phosphor of the present invention comprises aluminate which has been ascertained to emit fluorescence by UV excitation, and another metal component which is combined or doped to aluminate. Another object is to provide a method for producing such a phosphor efficiently.

DISCLOSURE OF THE INVENTION

An aluminate phosphor of the present invention which has solved the aforementioned problems successfully is represented by a general composition formula: $7(Sr_{1-x}Eu_x)O.yAl_2O_3$, wherein $0<x\leq 0.5$ and $1\leq y\leq 36$. This phosphor has a specific emission characteristic to emit light in a violet to blue-green region by UV excitation. Among the phosphor of the general composition formula provided above, particularly preferred is an aluminate phosphor of $0.001<x\leq 0.3$ and $3\leq y\leq 27$ in the general composition formula.

A producing method of the present invention is useful for manufacturing the aluminate phosphor of the general composition formula mentioned above, and is characterized by carrying out the following step (1) to the step (3) in order:

(1) a step of producing a powder of organic metal chelate complexes

including Sr, Eu and Al as metal components,

(2) a step of firing the powder obtained in the step (1) to obtain a multi metal oxide, and

(3) a step of reducing the multi metal oxide obtained in the step (2).

When the producing method of the present invention is practiced, in the step (1), mixing the metals mentioned above or compounds thereof and an organic chelating agent, and/or chelate complexes of the metals so as to be a predetermined metal composition; thereby forming a transparent aqueous solution of organic metal chelate complexes, followed by spray-drying the aqueous solution is preferred. It is possible to obtain an aluminate phosphor precursor having an extremely homogeneous metal composition ratio and a phosphor of substantially spherical fine particles and approximately uniform in particle size by the above method.

As the organic chelating agent used in a practice of this method, a complex consisting of an aminocarboxylic acid-based chelating agent and a metal ion, and/or salt thereof is particularly preferred.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a SEM image of a multi metal oxide powder. This powder was prepared by firing (Sr, Al, Eu)-EDTA complexes disclosed in the Examples at 800°C for 3 hours. Fig. 2 is an emission spectrum chart obtained when a phosphor film produced in the Examples was irradiated with UV rays of wavelength of 260 nm. Fig. 3 is a diagram showing the

relationship between an emission intensity when a phosphor film produced in the Examples is irradiated with UV rays of wavelength of 260 nm and an Al composition (x). Fig. 4 is an X-ray diffraction chart of a phosphor film produced in the Examples.

Fig. 5 shows an emission spectra obtained when a phosphor film irradiated with UV rays of wavelength of 260 nm. The phosphor film was prepared by dropping a multi metal oxide powder disclosed in the Examples on a multicrystalline alumina substrate, followed by drying and subsequently reducing under a flow of $Ar+H_2$ (3.8%) for 24 hours at 1200°C, 1300°C, 1350°C, or 1400°C.

BEST MODE FOR CARRYING OUT THE INVENTION

An UV-excited europium-activated strontium aluminate phosphor of the present invention is an aluminate phosphor represented by a general composition formula: $7(Sr_{1-x}Eu_x)O.yAl_2O_3$, wherein the amount x of Eu doped to Sr is within a range of $0<x\leq0.5$, and the proportion y of Al_2O_3 is within a range of $1\leq y\leq36$.

The range of the amount x of Eu doped is limited to $0<x\leq0.5$. When x is zero (0), in other words, no Eu is doped, an emission center is not formed and no emission occurs. When the amount of Eu doped is too much and the value of x exceeds 0.5, concentration quenching occurs and brightness of emission is diminished remarkably. For this reason, the value of x is defined as mentioned above in the present invention. A more preferable

range of the x is a range of $0.001 \leq x \leq 0.3$. In this range, the highest luminescent characteristics are demonstrated.

If the proportion y of Al_2O_3 is less than 1, a function as a phosphor is diminished and fluorescent emission does not occur enough. If y is over 36, fluorescent characteristics are not exhibited enough. For this reason, the value of y is defined to be within the range mentioned above in the present invention. A more preferable range of the y is a range of $3 \leq y \leq 27$. In this range, higher luminescent characteristics are demonstrated. When the value of y is 6, a phosphor is $Sr_{7(1-x)}Eu_{7x}Al_{12}O_{25}$ with a single phase as will be shown clearly in the Examples in a later section, which exhibits the highest luminescent characteristics.

The phosphor of the present invention satisfies the composition formula provided above and, therefore, it emits light in a violet to blue-green wavelength region by UV excitation. Especially it emits high-brightness fluorescence having a peak emission wavelength at about 410 nm, and its fluorescent lifetime is very short. This is in contrast to the strontium-aluminate-type phosphorescent material disclosed in the aforementioned prior art references, which have very long fluorescent lifetimes, in other words, which exhibit afterglow. The phosphor of the present invention has a metal composition ratio and a structure clearly different from those of the strontium-aluminate-type phosphorescent materials disclosed in the aforementioned prior art references, and therefore, these should be classified into different types of phosphor.

According to an X-ray diffraction analysis, as shown clearly in the Examples in a later section, the europium-activated strontium aluminate phosphor of the present invention wherein the y is 6 has a specific peak assigned to strontium aluminate "$7SrO.6Al_2O_3$", namely "$Sr_7Al_{12}O_{25}$". It comes to show many diffraction peaks as the y varies away from 6 (see Fig. 4 shown later). From this fact, it is considered that the aluminate phosphor of the present invention is consisted of a single phase rather than a plurality of phases. But there is quite a possibility that a plurality of phases are present together.

Although a method for producing the UV-excited europium-activated strontium aluminate phosphor of the present invention is not particularly restricted, it is possible to obtain the UV-excited europium-activated strontium aluminate phosphor more easily by using a powder of organic metal chelate complexes, as a precursor, in which metal components of Sr, Al and Eu are mixed homogeneously at a molecular level.

The organic metal chelate complexes serving as a precursor can be obtained easily by mixing metal compounds and an organic chelating agent so as to be a predetermined metal composition ratio, thereby forming a transparent aqueous solution of organic metal chelate complexes, followed by drying the aqueous solution using, for example, spray-drying.

For prevention of thermal decomposition during the drying process, preferably used as the organic chelating agent is an aminocarboxylic acid chelating agent which does not thermally decompose at temperatures of

about 200°C or lower.

In a preparation of an aqueous solution containing multi-element metal chelate complexes including Sr, Al and Eu as metal components, it is recommended to form a transparent aqueous solution by adding a chelating agent in the amount not less than the equivalent of the metals so that all the metal components form a complex completely. If part of the metal components precipitate as an insoluble compound during the preparation of the aqueous chelate complexes solution, a homogeneousness of the solution will be lost on the whole. In this case, it will become impossible to obtain a precursor powder in which the metal components are mixed homogeneously at a molecular level even if drying is conducted in any way. However, if a transparent chelate complexes solution in a complete dissolution state is prepared at this time, it is possible to easily obtain a powder of organic metal chelate complexes in which metal components are mixed homogeneously at a molecular level by spray-drying the solution.

The powder of chelate complexes is obtained as an amorphous powder, having a homogeneous composition at a molecular level, and having a substantially spherical appearance, and being approximately uniform in particle size. In addition, as shown clearly in the Examples in a later section, it is possible to obtain an aluminate phosphor powder having a substantially spherical shape and being approximately uniform in particle size. In this method for preparing the aluminate phosphor powder, a firing temperature can be remarkably lower than that used in a conventional

method for preparing a multi metal oxide phosphor or an aluminate phosphor (see Fig. 1 shown later).

In other words, the above-mentioned organic metal chelate complexes mixed three kinds of metal components homogeneously at a molecular level is an amorphous powder, and the organic metal complexes can be converted into a multi metal oxide by firing at a relatively low temperature in comparison to that used in conventional methods mentioned above (for example, a temperature is about 100°C to 250°C lower than that used in conventional methods). The resulting powder is substantially spherical and approximately uniform in particle size and has a very highly controlled composition due to the precursor material of the organic metal chelate complexes mixed homogeneously at a molecular level.

The organic metal chelate complexes mixed homogeneously at a molecular level, which is used in the present invention, shows a halo pattern caused by a scattering of incident X-rays and has non-crystalline structure. When the organic metal chelate complexes are instantaneously dried by spray-drying from a liquid phase, which is a homogeneous phase, it turns to a solid phase while the homogeneous phase is maintained. Thus, even if the organic metal chelate complexes are multi-element organic metal chelate complexes, it turns into a material which comprises complexes mixed homogeneously at a molecular level and which is non-crystalline where the molecules are agglomerated without taking a crystalline structure (in a microscopic view, although it is general that differences of a regularity

remaining in a structure are seen, such regularity is negligibly small, and therefore the resulting material is obviously distinguished from a crystalline complex).

Since the powder of the organic metal chelate complexes has a substantially spherical shape and is approximately uniform in particle size, firing this powder yields an aluminate phosphor that almost maintained its shape and particle size before the firing. Therefore, when a powdering condition used in the spray-drying is controlled properly, and a shape and particle size of the amorphous powder composed of the precursor multi metal chelate complexes is adjusted, it is possible to adjust a shape, particle size, and particle size distribution of the resulting aluminate phosphor powder at will.

The UV-excited europium-activated strontium aluminate phosphor produced from the amorphous powder can be used in various applications where UV rays are used as an excitation source because it has a substantially spherical shape and has no directionality as mentioned above. In particular, it is very suitable for a violet to blue-green phosphor used in three-wavelength fluorescent lamps, plasma displays, or the like.

The method for producing the UV-excited europium-activated strontium aluminate phosphor is described in more detail.

(1) In producing a phosphor of the present invention, a powder including organic metal chelate complexes of Sr, Eu and Al is prepared first. This preparation is conducted in the following manner, for example. First,

Sr and Eu are weighed out precisely so as to be a predetermined composition. Then Sr and Eu are allowed to react with an organic chelating agent, yielding a transparent aqueous solution containing organic metal chelate complexes. The reaction is carried out in an aqueous medium at a temperature, for example, from 20°C to a boiling point, preferably in a range from 50°C to 70°C. The concentration of the solution is preferably 5 mass % or more and 30 mass % or less, more preferably 10 mass % or more and 20 mass % or less. However, the conditions are not limited to such temperature or concentration ranges.

The amount of the organic chelating agent to be used is preferably equimolar to the metal ions, and more preferably 1.0 molar time or more and 1.5 molar times or less the metal ions. In the case that the metal chelate complexes or the organic chelating agent do not dissolve completely, it is recommended to dissolve them completely by adding ammonia, amine or the like. In another possible way, the organic metal chelate complexes of the metals are prepared separately, weighed out precisely and mixed so as to be a predetermined metal ratio.

Carbonates, nitrates, hydroxides and oxides can be used as metal sources. In the present invention, strontium and europium are preferred particularly to be used as oxides and carbonates, which are of high reactivity and which do not leave unwanted ions or the like after a reaction. Regarding aluminum, taking into consideration the reactivity with chelating agents, usable raw materials are limited substantially to chlorides, sulfates

and nitrates, and preferably nitrates. It is particularly preferable to prepare an aluminum chelate complex solution first by use of chloride, sulfate or nitrate, then produce high purity aluminum chelate complex crystals by crystallization, and use the crystals as an aluminum source.

The biggest problem in producing an aluminate phosphor is a contamination of impurity elements. If sodium salt or potassium salt of organic metal chelate complexes are used, such salts remain in the phosphor after thermal decomposition, and cause to change a composition of the phosphor. Accordingly, such salts should not be used. Inorganic acids containing chlorine, sulfur, phosphorus or the like, inorganic acid salts thereof (such as hydrochloric acid, sulfuric acid, phosphoric acid, or salts thereof), and organic substances (such as thiol compounds) are thermally decomposed in a firing process. However, it is desirable to use such acids, salts and organic substances as little as possible, because such acids, salts and organic substances may affect the production of a multi metal chelate complex with a homogeneous composition.

Examples of a chelating agent used in the present invention include aminocarboxylic acid-based water-soluble chelating agents such as ethylenediaminetetraacetic acid, 1,2-cyclohexanediaminetetraacetic acid, dihydroxyethylglycine, diaminopropanoltetraacetic acid, diethylenetriaminepentaacetic acid, ethylenediaminediacetic acid, ethylenediaminedipropionic acid, hydroxyethylenediaminetriacetic acid, glycoletherdiaminetetraacetic acid, hexamethylenediaminetetraacetic acid,

ethylenediaminedi(o-hydroxyphenyl)acetic acid, hydroxyethyliminodiacetic acid, iminodiacetic acid, 1,3-diaminopropanetetraacetic acid, 1,2-diaminopropanetetraacetic acid, nitrilotriacetic acid, nitrilotripropionic acid, triethylenetetraminehexaacetic acid, ethylenediaminedisuccinic acid, 1,3-diaminopropanedisuccinic acid, glutamic acid-N,N-diacetic acid and aspartic acid-N,N-diacetic acid. Any of monomers, oligomers and polymers thereof may be used.

A preferable chelating agent to be used is a free acid type, ammonium salt thereof, or amine salt thereof. It is desirable to select the most suitable one for each metal component to be used by considering a chelate formation constant with each metal, stability of a chelate complex and solubility of a chelate complex in water or alkaline aqueous solution.

The prepared aqueous solution containing the organic metal chelate complexes is powdered by spray-drying. Conditions of the spray-drying may be properly determined on the basis of a concentration of the solution, a processing rate of the solution, the amount of gas sprayed, the amount of hot air, or the like. The upper limit of a drying temperature preferably is a temperature at which an organic substance does not thermally decompose. A recommended temperature is where the solution is dried enough. From such a point of view, a preferred drying temperature range is approximately from 100°C to 200°C, and more typically from 140°C to 180°C. Considering such drying temperature, it is desirable to select a chelating agent that does not thermally decompose at a temperature of about 200°C or lower. In the

present invention, an aminocarboxylic acid-based chelating agent is used.

(2) The powder obtained in the step (1) is converted into a metal oxide powder by firing.

Conditions preferred in this operation are as follows: When the amorphous powder obtained in the step (1) is fired without being processed beforehand, an organic component is thermally decomposed and the amorphous powder is converted into a composite oxide powder. What is required of the firing is only that an organic component is decomposed completely. For example, when the amorphous powder is fired at a temperature of 500°C or higher, all organic components are decomposed away and a multi metal oxide remains. Raising a firing temperature improves a crystallinity of the multi metal oxide. Therefore, it is possible to fire the amorphous powder at temperatures up to 1500°C, as required. It is not necessary to be conducted the firing or the heat treatment in the air. The firing or the heat treatment may be conducted in an oxygen-rich atmosphere, a neutral atmosphere or a reducing atmosphere according to needs.

(3) The multi metal oxide powder is then subjected to reducing treatment to reduce europium to divalent, and thereby is converted to the UV-excited europium-activated strontium aluminate phosphor. The reducing treatment is conducted by heating the precursor powder in a reducing atmosphere. A heating temperature ranges preferably from 500°C to 1600°C, and more preferably from 1000°C to 1500°C. As shown clearly in

the Examples in a later section, when the heat treatment is carried out in a reducing atmosphere at about 1400°C (approximately 1400°C±10°C), it is possible to obtain a very strong fluorescence having a peak emission wavelength at about 410 nm (see, Fig. 5). Although the reducing atmosphere is not particularly restricted, mixed atmosphere of argon and hydrogen or nitrogen and hydrogen is preferred.

The step (2) and the step (3) may be carried out in different furnaces. It is also possible to carry out the step (2) and the step (3) continuously in one furnace by changing a firing atmosphere and temperature. Treating the multi metal oxide powder obtained in the step (2) directly in the step (3) yields a powdery phosphor. On the other hand, when the multi metal oxide powder obtained in the step (2) is applied onto a heat-resistant substrate to form a thin film, and then is subjected to the treatment in the step (3), it is possible to produce a phosphor film.

According to the present invention as described above, it is possible to provide a novel UV-excited europium-activated strontium aluminate phosphor represented by a general composition formula: $7(Sr_{1-x}Eu_x)O.yAl_2O_3$, wherein $0<x\leq0.5$ and $1\leq y\leq36$. The aluminate phosphor of the present invention emits light in a violet to blue-green region in a wide strontium/aluminum composition range. In addition, according to the producing method of the present invention described above, it is possible to produce the phosphor with a homogeneous composition at a molecular level efficiently and certainly. The phosphor of the present invention is produced

by using, as a raw material, a powder including organic metal chelate complexes mixed homogeneously at a molecular level.

As described above, the powder of the organic metal chelate complexes used in the practice of the present invention is produced by mixing metals as raw materials and an organic chelating agent so as to be a predetermined metal composition, thereby forming a transparent aqueous solution containing organic metal chelate complexes, and then drying the aqueous solution. For the drying in this process, spray-drying is preferable. This is because the spray-drying can dry a solution instantaneously while maintaining a homogeneous phase of a liquid phase state, and it is possible to easily obtain substantially spherical fine particles which are approximately uniform in particle size. As the organic chelating agent to be used in the invention, an aminocarboxylic acid-based chelating agent is preferably used.

The UV-excited europium-activated strontium aluminate phosphor of the present invention is applied to what uses UV rays as an excitation source. In particular, the phosphor of the invention can be used effectively as a violet to blue-green emitting phosphor to be used in three-wavelength fluorescent lamps, plasma displays, or the like.

EXAMPLES

Hereinafter, the present invention will be described in detail by Examples, but the following Examples do not limit the present invention,

and modifications which do not depart from the spirit and the scope of the present invention are included in the present invention.

Example 1

Into a 1-liter beaker, 217 g of ethylenediaminetetraacetic acid and water were added to an overall amount of 500 g, and then 100 g of aqueous ammonia was added and dissolved. While the solution was stirred, 110 g of strontium carbonate was added slowly and was dissolved completely by heating up to 100°C, and the mixture was stirred for two hours. The concentration of the resulting solution was adjusted by addition of water, and a colorless transparent aqueous solution of strontium-ethylenediaminetetraacetic acid (Sr-EDTA) complex was obtained.

Separately, into a 100-ml beaker, 0.65 g of ethylenediaminetetraacetic acid and water were added to an overall amount of 100 g and then 0.3 g of aqueous ammonia was added and dissolved. While the solution was stirred, 0.4 g of europium oxide was added and the mixture was stirred at 80°C for 30 minutes. The europium oxide was dissolved completely and a solution of europium-ethylenediaminetetraacetic acid (Eu-EDTA) was obtained.

The Sr-EDTA complex solution (Sr content: 4.41 mass %), the Eu-EDTA complex solution (Eu content: 0.440 mass %) and ethylenediaminetetraacetic acid aluminum ammonium (EDTA.Al.NH_4) (Al

content: 7.13 mass %) were weighed out precisely as shown in the following Table 1 and placed in a 100-ml beaker. Then water was added to an overall amount of 100 g. The solution was stirred for 30 minutes to achieve complete dissolution. A colorless transparent aqueous solution of (Sr, Al, Eu)-EDTA complexes having a metal component composition of (Sr+Eu)/Al in the range of 7/6 to 7/54 and Eu/Sr of 0.02/0.98 was yielded. The solution was powdered by spray-drying at a drying temperature of 160°C, and a powder of (Sr, Al, Eu)-EDTA complexes was obtained. An X-ray diffraction chart of this powder was examined. A halo pattern caused by a scattering of incident X-rays appeared, which shows that a crystal structure of the powder was amorphous (non-crystalline).

The complex powder was pre-fired at 800°C for 3 hours in an air-releasable electric furnace to remove organic substances. Thus, a multi metal oxide powder was obtained. Fig. 1 is a SEM image of the powder, and it can be confirmed that the powder is approximately uniform in particle size and has a substantially spherical shape. 0.01 g of the resulting multi metal oxide powder was dispersed in ethanol. The ethanol solution of multi metal oxide was dropped on a multicrystalline alumina substrate sized 10 mm × 10 mm, was dried, and further was reduced under a flow of Ar+H_2 (3.8%) at 1400°C for 24 hours to obtain a phosphor film.

The phosphor film was excited by UV at 260 nm. An emission spectrum of the phosphor film is shown in Fig. 2 (in the chart, numerals indicate experiment numbers). The emission intensity measured when UV

rays of wavelength of 260 nm was irradiated is shown in Fig. 3 (in the chart, numerals indicate experiment numbers). These charts clearly show that a high-brightness fluorescence in a region from violet to blue is emitted in the (Eu+Sr)/Al range of 7/6 to 7/54. Especially, the highest brightness is demonstrated at (Eu+Sr)/Al of 7/12.

Fig. 4 shows X-ray diffraction patterns of the phosphor obtained in each experiment. This chart confirms that a single phase of $Sr_7Al_{12}O_{25}$ was obtained in the phosphor having a (Eu+Sr)/Al of 7/12 which demonstrated the highest brightness. Table 2 shows emission peak wavelengths of the phosphor films obtained above. It is ascertained that they are blue phosphor having a peak wavelength at about 410 nm.

TABLE 1

Experiment No.	(Sr+Eu)/Al	Eu/Sr	Sr-EDTA complex solution (g)	EDTA.aluminum. ammonium (g)	Eu-EDTA complex solution (g)
1	7/6	0.02/0.98	41.883	6.983	14.865
2	7/8	0.02/0.98	36.852	8.193	13.080
3	7/12	0.02/0.98	29.715	9.909	10.546
4	7/14	0.02/0.98	27.091	10.539	9.615
5	7/18	0.02/0.98	23.025	11.517	8.172
6	7/36	0.02/0.98	13.743	13.749	4.878
7	7/54	0.02/0.98	9.795	14.698	3.476

TABLE 2

Experiment No.	Peak emission wavelength (nm)
1	412
2	413
3	412
4	412
5	408
6	406
7	406

Example 2

The solution of (Sr, Al, Eu)-EDTA complexes was dropped on a multicrystalline alumina substrate sized 10 mm × 10 mm, was dried, and further was reduced under a flow of Ar+H_2 (3.8 volume %) at 1200°C, 1300°C, 1350°C or 1400°C for 24 hours to obtain a phosphor film. The complex solution dropped on an alumina substrate was a solution having a (Eu+Sr)/Al of 7/12 (Experiment No. 3 in Table 1) of Example 1. Fig. 5 shows an emission spectrum obtained when the phosphor film was irradiated with UV rays of wavelength of 260 nm. As clear from this chart, a blue-emitting phosphor having a peak wavelength at about 410 nm was obtained when the reducing treatment was carried out at about 1400°C.

INDUSTRIAL APPLICABILITY

The UV-excited europium-activated strontium aluminate phosphor of the present invention represented by the general composition formula shown above emits characteristic fluorescence in a violet to blue-green region by UV excitation. The phosphor of the present invention is very useful as an UV-excited phosphor. In particular, the phosphor of the present invention has a peak emission wavelength at about 410 nm, and has a peak wavelength different from that of a conventional blue-emitting phosphor. According to the producing method of the present invention, it is possible to produce the UV-excited phosphor with the aforesaid characteristics efficiently. It is also possible to obtain the phosphor as a fine powder being homogeneous in metal composition ratio, having a substantially spherical shape, and being approximately uniform in particle size. Thus, it is possible to provide the phosphor which can be used widely in a variety of applications effectively.